Low Tapping Frequency to Increase Productivity in Thailand

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Abstract

The purpose of this study was to assess tapping systems to decrease tapping frequency with stimulation in order to increase yield per day and tapper productivity. This experiment was set up in Chachoengsao Rubber Research Center since 2016. Experimental design was a Split plot comprising 4 replications. 3 main treatments are clones (RRIT 251, RRIM 600 and PB 235) and 4 sub-treatments are tapping systems (S/2 d2, S/3 d1 2d3, S/2 d3 ET2.5% without recovery of lost tapping days and S/2 d3 ET2.5% with recovery of lost tapping days). Three years of tapping showed that RRIT 251 and PB 235 increased yield by 62% and 27% in comparison with RRIM 600. Regarding sub-treatments, S/2 d3 ET2.5% and S/2 d3 ET2.5% with recovery of lost tapping days could increase productivity per day (g/t/t) by 18-23%. Yield in term of kilogram per tree per year was not significantly different among tapping systems. Tapping days in d3 were only 71-81 days per year and less than for d2 and d1 2d3 with 107 and 138 tapping days per year respectively.

Key word: *Hevea brasiliensis*, Tapping system, Low frequency tapping system, intensive tapping system, yield, tapper productivity,

1. Introduction

Thailand represents 23% of the total area under *Hevea brasiliensis* in the world, and 35.5% of total natural rubber production, with 4.75 million tons produced in 2018. Rubber producers are mainly smallholders who represent more than 85% of the total rubber area in the country. The concept of Good Agricultural Practices (GAP) is application of available knowledge to the utilization of the natural resource base in a sustainable way for the production of safe, healthy food and non-food agricultural products in a human manner while achieving economic viability and social stability. In rubber plantations, it includes good techniques of tapping that result in less bark damage and controlled and reduced bark consumption. Right technique is to control depth and angle of cut and to maintain the backward and forward vertical lines, cleaning of spouts, cups and buckets and to control the latex quality. Objective of this study is to increase productivity and sustainablity in latex quality from farms to factory. While GAP is to conserve environment and reduce wastages, control on tapping quality to prolong the lifespan is also focused in the rubber plantations.

Rubber producers are mainly smallholders who represent more than 85% of the total rubber area in the country. They mainly use high tapping frequencies (d1 2d/3) combined with a reduced tapping cut length (S/3) resulting in a rather low output per tapper per day. Main physiological and practical causes for this low output per tapper are known. The insufficient time for latex regeneration between consecutive tappings because of too high tapping frequencies, reduces output per tree per tapping (Jacob et al., 1988, 1995, d'Auzac *et al*., 1997) and prevents the use of ethephon stimulation because of insufficient latex sugar content (Tupy and Primot, 1976, Low and Gomez, 1982). The high tapping panel dryness rate occurs with such intensive tapping systems (Anekachai, 1989). The control upward tapping (CUT) is still difficult when using such intensive tapping frequencies. Low tapping frequency have already been experimented to improve rubber productivity. This strategy has been successfully used in rubber plantations worldwide, using tapping systems like S/2 d3 or S/2 d4 (Abraham, 1970, Paardekooper *et al*., 1975, Eschbach and Tonnelier, 1984, Eschbach and Banchi, 1985, Eschbach, 1986, Gohet, 1996, Gohet *et al*., 1991, 1996, 1997).

Physiological background of low tapping frequency lays on optimization of available time for latex regeneration, as complete regeneration generally requires 48-72 hours depending on clone latex metabolism. As a consequence, output per tapping of S/2 d2 reference tapping system is actually limited as well by a short regeneration time interval between consecutive tappings (Jacob *et al*., 1988, 1995). Therefore theoretically result in an improved latex regeneration and an increased output per tree per tapping. It might be theoretically possible to optimize exploitation tapping system by using appropriate stimulation intensity on each cut as d/4 tapping frequency can be optimized using ethephon stimulation (Eschbach and Tonnelier, 1984, Eschbach and Banchi, 1985, Eschbach, 1986, Gohet *et al.,* 1991, 1996, 1997, Lacrotte *et al*., 1985, Lacote *et al*, 2010). Recently medium and estate farms will tapped with d3 to conserve bark and increase productivity according to low rubber price and lack of skill tapper.

2. Material and Methods

The study presents results obtained during the first 3 years of tapping of one large scale trial set up on RRIM600 clone at the Chachoengsao Rubber Research Centre, RRIT-DOA, Thailand in May 2016. This experiment is a "Spilt plot" comprising 3 main treatments (clone): RRIT 251, PB 235 and RRIM 600 and 4 sub-treatments (Tapping systems, A to D) and 4 replications. Detailed protocol of the studied treatments is presented in Table 1.

Table 1: Experimental protocol. Large scale tapping trial, Split plot in RCB, 4 subplots. Stimulations per year 2.5% ET

Treatments	1st&2nd years of tapping			3rd year of tapping		
	RRIT 251	RRIM 600	PB 235	RRIT 251	RRIM 600	PB 235
A. S/2 d1 d2 7d/7 9m/12	-	-	-	-	-	-
B. S/3 d1 2d3 7d/7 9m/12	4	4	4	4	4	4
C. S/2 d3 7d/7 9m/12 ET 2.5% Pa 0.7 (1)	5	5	4	6	6	5
D. S/2 d3 7d/7 9m/12 ET 2.5% Pa 0.7 (1) 4/Y 7d/7 9m/12 Recovery of tapping days	4	4	3	5	5	4

First opening has been performed in May 2016. Rubber trees in treatment A and B were opened at 1.50m from the ground on panel BO-1 while C and D were opened at 1.30m from the ground. All treatments were tapped 7d/7 9m/12, since re-foliation and dry season, associated with very high temperatures, prevent economic tapping in February, March and April in the Chachoengsao area. Stimulation was performed using 2.5% ethephon concentration (0.7 g/tree/application) applied to the bark under regeneration just above the tapping cut on 1 cm : ET 2.5% Pa 0.7 (1) according to Vijayakumar *et al* (2009). Stimulant applications are evenly distributed from May to December, depending on stimulation frequency of each treatment. The 1st and 2nd tapping year, treatments C and D were stimulated 5 and 4 times per year in RRIT 251 and RRIM 600 while PB 235 was stimulated 4 and 3 times per year. The 3rd tapping year they were stimulated 6 and 5 times per year in RRIT 251 and RRIM 600 while PB 235 was stimulated 5 and 4 times per year.

Studied parameters were dry rubber production (g/t/t, kg/t/y, kg/ha/y, kg/ha/d) girth and annual radial growth (expressed in cm and measured at 1.70 m from the ground). Latex biochemical parameters (sucrose [Suc], inorganic phosphorus [Pi] and reduced thiols [R-SH]) were measured once a year in October, when latex metabolic activity is the highest (Chantuma *et al*. 2001), and analyzed using the methods developed for "Latex Diagnosis" (Eschbach *et al.* 1984, Jacob *et al.* 1985, 1988a, 1988b) and updated for Thailand by Gohet and Chantuma (1999). Physiological parameters concentrations are expressed in mM/litre of latex.

The trial was conducted during 3 years, since 2015 until 2019, at the Chachoengsao Rubber Research Station in east Thailand (13°36' north, 101°27' east, altitude 45 m above sea level). The climate is subtropical, characterized by temperature amplitudes o 25°C to 35°C, a high humidity (80% to 90%) and rainfall of up to 1,200 mm

Plant material

Three rubber clones (RRIT 251, PB 235 and RRIM 600) were used. Two of them (RRIM600 and RRIT251) are the most planted in Thailand.

Experimental design

During the 3-year experimental period, trees were compared under 4 tapping systems. For each treatment, the experimental plot was 0.16 ha. Trees were spaced at 7 m × 3 m (476 trees ha^{-1}). The experimental design was a "Split-plot" comprising 3 main treatments (clone RRIT 251, PB 235 and RRIM 600), combined with 4 subtreatments (A to D) and 4 replications with 70 trees per treatment. Trees, at the time of the beginning of the trial were 9 years old. Trees of equal size were selected. First opening was performed in May 2016. The tapping cut was located 1.50 m from the ground, at the trunk girth of 50 cm. Every two days, the trees were tapped with a half spiral downward cut (A. S/2 d2 7d/7). Treatment B were tapped with one-third spiral downward cut, tapped two days continued and stop 1 day. Treatment C and D were tapped with a haft spiral downward cut, tapped every three days with stimulation 2.5% and number of stimulation followed table 1. In treatment D, lost tapping days due to the rain were recovered

Measurements and data processing

The latex yield per tree was measured by weighing the cumulative coagulated rubber from each tree every four weeks. Total solid content was measured from a bulk sample taken in each treatment in order to convert fresh weights into grams of dry rubber per tree. Latex yield was expressed in grams per tree (g/tree). Bark consumption were measured every year.

The main latex biochemical parameters, i.e. sucrose (Suc) and inorganic phosphorus (Pi) contents, were measured from a bulk sample of 10 trees taken in each treatment, in each replication, each year in October, when latex metabolic activity is the highest (Chantuma et al. 2001), using methods developed by CIRAD and CNRA (Jacob *et al.*, 1988 and 1995) adapted in 1995 by IRRDB (1995). Sucrose and inorganic phosphorus contents were expressed in millimoles per litre of latex (mmol l^{-1}). Sucrose content was measured using the Ashwell anthrone method (1957). Inorganic phosphorus (Pi) content was measured using the Taussky and Shorr method (1953).

A two ways ANOVA was performed to compare main treatment, sub-treatment and interaction. All differences were tested for statistical significance using the Duncan test with an alpha threshold of 0.05. Statistical analyses of latex yield and biochemical parameters were performed using Xlstat.

3. Results

3.1. First year of tapping

Yield

Average yield per tapping (g/t/t); Clones RRIT 251 and PB 235 respectively produced 43.29 and 35.63 g/t/t, significantly more than RRIM 600 (28.81 g/t/t). Treatment C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery of tapping days produced respectively 44.82 and 41.92 g/t/t, significantly more than A. S/2 d/2 and B. S/3 d1 2d/3 (32.28 and 24.64 g/t/t). Interaction between clone and tapping system showed that clone RRIT 251 & C. S/2 d3 ET2.5% 4-5/y and RRIT 251 & D. S/2 d3 ET2.5% 3-4/y with recovery of tapping days, PB 235 & C. S/2 d3 ET2.5% 4-5/y and PB 235 & D. S/2 d3 ET2.5% 3-4/y with recovery of tapping days respectively produced 55.24, 50.56, 44.63 and 41.07 g/t/t, significantly higher than others (table 2).

Cumulative yield (kg/t/y); Clone RRIT 251 produced 4.03 kg/t/y, significantly more than PB 235 and RRIM 600 (3.32 and 2.72 kg/t/y). Treatments A-D yield (3.18-3.45 kg/t/y) were not significantly different, although tapped days were only 107, 71 and 81 days/year in A. S/2 d/2, C.

S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery of tapping days respectively, compared to 138 days for B. S/3 d1 2d/3 (table 3).

Cumulative yield (kg/ha/y); Clone RRIT 251 produced 1,890 kg/ha/y significantly higher yield than PB 235 and RRIM 600 (1,558 and 1.274 kg/ha/y). Treatments A-D (1,492-1,619 kg/ha/y) were not different significant (table 4).

Latex diagnosis

DRC (%); Clone RRIT 251 (45.65%) was significantly higher than RRIM 600 and PB 235 (40.46 and 38.64%). Treatments A-D (38.64-44.46%) were not significantly different. Interaction between clone and tapping system showed that clones RRIT 251 and PB 235 with treatment A-D (42.23-50.73% and 37.58-39.95%) were not significantly different while RRIM 600 & D. S/2 d3 ET2.5% 3-4/y with recovery obtained a lower DRC (36.11%) than others (table 5)

Sucrose (Suc, mM/l); clone PB 235 (11.34 mM/l) was significantly higher than RRIT 251 and RRIM600 (8.48 and 7.00 mM/l respectively). Treatments A-D (7.91-9.44 mM/l) were not significantly different (table 6).

Inorganic phosphorus (Pi, mM/l); clone RRIT 251 (25.65 mM/l) was significantly higher than PB235 and RRIM600 (19.15 and 11.44 mM/l respectively). Treatments A-D (17.89-19.80 mM/l) were not significantly different (table 7).

Thiol (RSH, mM/l); clones RRIM 600 and RRIT 251 (0.33 mM/l) were significantly higher RSH than PB235 (0.22 mM/l). Treatments A-C (0.29-0.31 mM/l) were significantly higher than D (table 8). Interaction between clone and tapping system showed clones RRIM 600 and RRIT 251 with treatment A (0.37 and 0.38 mM/l) were significantly higher than B-D. In the contrary, PB 235 with treatment A (0.17 mM/l) was the lowest compared with the others.

3.2. Second year of tapping

Average yield per tapping (g/t/t): Clone RRIT 251 produced 53.90 g/t/t, significantly more than PB 235 and RRIM 600 (35.63 and 28.81 g/t/t). Treatments A. S/2 d/2, C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery (39.70-47.80 g/t/t) were significantly higher yield than B. S/3 d1 2d3 (29.80 g/t/t). Interaction between clone and tapping system showed that clone RRIT 251& A. S/2 d/2, RRIT 251 & C. S/2 d3 ET2.5% 4-5/y and RRIT 251 & D. S/2 d3 ET2.5% 3-4/y with recovery, PB 235 & C. S/2 d3 ET2.5% 4-5/y and PB 235 & D. S/2 d3 ET2.5% 3-4/y recover tapping day (52.48, 63.87, 60.34, 44.63 and 41.70 g/t/t respectively) were significantly higher than others (table 9).

Cumulative yield (kg/t/y): Clone RRIT 251 produced 4.69 kg/t/y, significantly more than PB 235 and RRIM 600 (3.25 and 2.76 kg/t/y). Treatments A-D (3.20-3.87 kg/t/y) were not significantly different although tapping days were 97, 67 and 72 days/year in A. S/2 d/2, C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery respectively and were less tapped days than B. S/3 d1 2d/3 (130 days/year) (table 10). Interaction between clone and tapping system showed that clones RRIT 251 and PB 235 with treatment A-D were not significantly different while RRIM 600 & A. S/2 d/2 and RRIM 600 & B. S/3 d1 2d/3 (3.00 and 3.23 kg/t/y) were significantly higher than RRIM 600 with C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery (2.31 and 2.50 kg/t/y).

Cumulative yield (kg/ha/y): Clone RRIT 251 produced 2,200 kg/ha/y, significantly more than PB 235 and RRIM 600 (1,523 and 1,294 kg/ha/y). Treatments A-D (1,501-1,816 kg/ha/y) were not significantly different. Interaction between clone and tapping system showed that clones RRIT 251 and PB 235 with treatment A-D were not significantly different while RRIM 600 & A. S/2 d/2 and RRIM 600 & B. S/3 d1 2d/3 (1,409 and 1,516 kg/ha/y) were significantly higher

than RRIM 600 with C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recoverytapping day (1,082 and 1,171 kg/t/y) (table 11).

Bark consumption

Among clones RRIT 251, RRIM 600 and PB 235, consumed bark (18.77, 19.74 and 18.80 cm/y) was not significantly different. Treatments C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery consumed bark 15.00 and 16.00 cm/y respectively, significantly less than A. S/2 d/2 and B. S/3 d1 2d3 (19.10 and 26.35 cm/y). (table 12)

Latex diagnosis

DRC (%): Clones RRIT 251, RRIM 600 and PB 235 (46.35, 45.03 and 45.49%) were not significantly different. Among treatments, DRC (45.10-46.05%) were not significantly different and there was no significant interaction between clones and treatments (table 12).

Sucrose (Suc, mM/l): Clones RRIT 251 and PB 235 (11.05 and 10.09 mM/l) were significantly higher than RRIM 600 (7.94 mM/l). Treatments A-D (8.17-10.32 mM/l) were not significantly different. Interaction between clones and tapping systems showed that RRIT 251 with treatments B-D (11.28-13.00 mM/l) were significantly higher Suc than RRIT 251 & A. PB 235 & A and PB 235 & D (11.34 and 12.58 mM/l) were significantly higher than others (table 14).

Inorganic phosphorus (Pi, mM/l): Clones RRIT 251, RRIM 600 and PB 235 (15.16-18.19 mM/l) were not significantly different. Among treatments, Pi (14.70-17.90 mM/l) were not significantly different. Interaction between clones and tapping systems showed that PB 235 with treatments A-C and RRIT 251 with treatment C (18.01-21.02 mM/l) were significantly higher than others (table 15).

Thiol (RSH, mM/l): Clones RRIT 251, RRIM 600 and PB 235 (0.50-0.56 mM/l) were not different significant. Among treatments, RSH (0.49-0.59 mM/l) were not significantly different and there was no significant interaction between clones and treatments (Table 16).

3.3. Third year of tapping

Yield

Average yield per tapping (g/t/t); Clone RRIT 251 produced 50.30 g/t/t, significantly more than PB 235 and RRIM 600 (36.76 and 31.15 g/t/t). Treatment A. S/2 d/2, C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery produced yield 40.18-44.85 g/t/t significantly higher yield than B. S/3 d1 2d/3 (29.35 g/t/t). Interaction between clone and tapping system found clone RRIT 251 & C. S/2 d3 ET2.5% 4-5/y and RRIT 251 & D. S/2 d3 ET2.5% 3-4/y with recovery produced yield 62.45 and 55.79 g/t/t respectively, significantly more than others (table 17).

Cumulative yield (kg/t/y); Clone RRIT 251 produced 4.57 kg/t/y, significantly more than PB 235 and RRIM 600 (3.40 and 2.92 kg/t/y). Treatments (3.18-3.94 kg/t/y) were not significantly different though tapped days were 98, 71 and 80 days/year in A. S/2 d/2, C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery respectively, compared to 134 days for B. S/3 d1 2d/3 (134) (table 18). Interaction between clone and tapping system showed that clone RRIT 251 and PB 235 with treatment A-D were not significantly different while RRIM 600 & A. S/2 d/2 and RRIM 600 & B. S/3 d1 2d/3 obtained 3.40 and 3.38 kg/t/y, significantly higher than RRIM 600 with C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y recover tapping day (2.33 and 2.55 kg/t/y).

Cumulative yield (kg/ha/y); Clone RRIT 251 produced yield 2,142 kg/ha/y, significantly more than PB 235 and RRIM 600 (1,593 and 1,367 kg/ha/y). Yields of treatments A, B and D were

1,846, 1,843 and 1,621 kg/ha/y respectively, significantly higher than C. Interaction between clone and tapping system showed that clones RRIT 251 and PB 235 with treatment A-D were not significantly different while RRIM 600 & A. S/2 d/2 and RRIM 600 & B. S/3 d1 2d3 produced 1,594 and 1,586 kg/ha/y, significantly higher than RRIM 600 with C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y recover tapping day (1,090 and 1,196 kg/t/y) (table 19).

Bark consumption

Among clones RRIT 251, RRIM 600 and PB 235, consumed bark (18.02, 16.68 and 18.34 cm/y) was not significantly different. Treatments C. S/2 d3 ET2.5% 4-5/y and D. S/2 d3 ET2.5% 3-4/y with recovery consumed significantly less bark (15.73 and 13.90 cm/y) than A. S/2 d/2 and B. S/3 d1 2d3 (18.70 and 23.62 cm/y). (table 20).

Latex diagnosis

DRC (%); Clones RRIT 251, RRIM 600 and PB 235 (43.95, 46.20 and 45.53%) were not significantly different. Among treatments A-D DRC (44.06-46.58%) were not different significant and there was no interaction between clones and treatments (table 21).

Sucrose (Suc, mM/l); RRIT 251 and PB 235 Suc were 9.30 and 10.93 mM/l, significantly higher than RRIM 600 (6.37 mM/l). Treatments A-D (7.24-10.02 mM/l) were not significantly different. Interaction between clone and tapping system showed that clone RRIT 251 with treatments B-D (8.86-10.69 mM/l) was significantly higher than RRIT 251 & A. RRIM 600 & A showed significantly lower Suc than the others (table 22).

Inorganic phosphorus (Pi, mM/l); RRIT 251, RRIM 600 and PB 235 Pi 20.46-26.16 mM/l were not different significant. Among treatment A-D Pi 22.73-24.58 mM/l were not significantly different and there was no interaction between clones and treatments (table 23).

Thiol (RSH, mM/l); Clone RRIT 251, RRIM 600 and PB 235 RSH 0.16-0.20 mM/l were not different significant. Among treatment A-D RSH 0.16-0.21 mM/l were not different significant and no interaction between clones and treatments (table 16).

4. Discussion and Conclusion

Actually treatments A. S/2 d2 and B. S/3 d1 2d3 are RRIT recommendations for Thai smallholders. On this experiment, the first three years of tapping showed that S/2 d3 tapping system (C. S/2 d3 without recovery of lost tapping days and D. S/2 d3 without recovery of lost tapping days) could increase the average yield expressed in g/t/t (labor productivity per tapping). It produced the same cumulative yield in terms of kg per tree (kg./t/y) and kg per area (kg/ha/y), although the number of yearly tapping days was significantly less than d1 2d3 (67 and 57 days respectively) and less than d2 (26 and 36 days respectively). All treatments were not different regarding latex diagnosis parameters, proving that they reached a similar metabolic status. Clones RRIT 251 and PB 235 obtained a significant higher yield than RRIM 600 and responded better than RRIM600 to the tapping frequency reduction with stimulation, especially in years 2 and 3.

Such tapping systems with reduced tapping frequency, like S/2 d3, with or without recovery of lost tapping days, are to be more studied in Thailand, as they could be the way to maintain the yield per land and to increase the labor productivity. This would in particular permit the adaptation to a possible shortage of tappers, even under the Thai smallholders context of share-cropping, or the development of other on-farms activity (diversification) in order to mitigate the effect of low rubber prices, reducing the time spent in plantation by tappers to produce the same quantity of rubber and releasing time to do something else.

Acknowledgement

Many thanks are due to our assistants in Chachoengsao Rubber Research Center, for their hard work and support for this study.

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Table 2 Rubber clones and tapping systems on yield (g/t/t) in the 1st year of tapping

Tapping system	Tapping day	Yield (g/t/t)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	107	38.39 b	26.05 c	32.38 b	32.38 b
B. S/3 d1 2d/3	138	28.98 c	21.11 c	23.82 c	24.64 c
C. S/2 d3 ET 2.5 % 4-5/y	71	55.24 a	34.58 b	44.63 a	44.82 a
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	81	50.56 a	33.49 b	41.70 a	41.92 a
average		43.29 a	28.81 c	35.63 b	
CV a (%) = 12.5		CV b (%) =	12.2		

Table 3 Rubber clones and tapping systems on yield (kg/t/y) in the 1st year of tapping

Tapping system	Tapping day	Yield (kg/t/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	107	4.11	2.79	3.46	3.45
B. S/3 d1 2d/3	138	4.00	2.91	3.29	3.40
C. S/2 d3 ET 2.5 % 4-5/y	71	3.92	2.45	3.17	3.18
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	81	4.10	2.71	3.38	3.40
average		4.03 a	2.72 c	3.32 b	
CV a (%) = 16.1		CV b (%) =	11.6		

Table 4 Rubber clones and tapping systems on yield (kg/ha/y) in the 1st year of tapping

Tapping system	Tapping day	Yield (kg/ha/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	107	1,926	1,307	1,624	1,619
B. S/3 d1 2d/3	138	1,875	1,366	1,541	1,594
C. S/2 d3 ET 2.5 % 4-5/y	71	1,839	1,151	1,485	1,492
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	81	1,920	1,272	1,583	1,592
average		1,890 a	1,274 c	1,558 b	
CV a (%) = 13.2		CV b (%)	9.8		

Table 5 Rubber clones and tapping systems on latex diagnosis in the 1st year of tapping

Tapping system	DRC (Dry rubber content, %)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	43.25	43.28	37.61	41.37 b
B. S/3 d1 2d/3	50.73	42.68	39.95	44.46 a
C. S/2 d3 ET 2.5 % 4-5/y	46.42	39.77	39.41	41.87 b
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	42.23	36.11	37.58	38.64 b
average	45.65 a	40.46 b	38.64 c	
CV a (%) =13.2	CV b (%)	9.8		

Table 6 Rubber clones and tapping systems on latex diagnosis in the 1st year of tapping

Tapping system	Sucrose ([Suc], mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	8.82	6.93	11.66	9.13
B. S/3 d1 2d/3	8.87	7.01	12.04	9.31
C. S/2 d3 ET 2.5 % 4-5/y	7.21	6.49	10.03	7.91
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	9.05	7.60	11.66	9.44
average	8.48 b	7.00 b	11.34 a	
CV a (%) =11.2	CV b (%)	10.1		

Table 7 Rubber clones and tapping systems on latex diagnosis in the 1st year of tapping

Tapping system	Inorganic phosphorus (Pi, mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	23.61	10.66	19.39	17.89
B. S/3 d1 2d/3	25.53	9.98	18.26	17.92
C. S/2 d3 ET 2.5 % 4-5/y	27.00	11.83	19.33	19.39
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	26.45	13.30	19.66	19.80
average	25.65 a	11.44 c	19.15 b	
CV a (%) =12.5	CV b (%)	9.5		

Table 8 Rubber clones and tapping systems on latex diagnosis in the 1st year of tapping

Tapping system	Thiol ([RSH] mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	0.38	0.37	0.17	0.31
B. S/3 d1 2d/3	0.29	0.31	0.25	0.29
C. S/2 d3 ET 2.5 % 4-5/y	0.29	0.35	0.27	0.30
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	0.20	0.30	0.21	0.24
average	0.29 a	0.33 a	0.22 b	
CV a (%) =14.5	CV b (%)	10.5		

Table 9 Rubber clones and tapping systems on yield (g/t/t) in the 2nd year of tapping

Tapping system	Tapping day	Yield (g/t/t)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	97	52.48 a	26.05 c	32.38 b	39.70 a
B. S/3 d1 2d/3	130	38.92 b	21.11 c	23.82 c	29.80 b
C. S/2 d3 ET 2.5 % 4-5/y	67	63.87 a	34.58 b	44.63 ab	47.80 a
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	72	60.34 a	33.49 b	41.70 ab	46.42 a
average		53.90 a	28.81 c	35.63 b	
CV a (%) = 13.5		CV b (%) =	12.1		

Table 10 Rubber clones and tapping systems on yield (kg/t/y) in the 2nd year of tapping

Tapping system	Tapping day	Yield (kg/t/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	97	5.09 a	3.00 b	3.46 b	3.85
B. S/3 d1 2d/3	130	5.06 a	3.23 b	3.33 b	3.87
C. S/2 d3 ET 2.5 % 4-5/y	67	4.28 a	2.31 c	3.02 b	3.20
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	72	4.34 a	2.50 c	3.19 b	3.34
average		4.69 a	2.76 c	3.25 b	
CV a (%) = 15.9		CV b (%) =	13.6		

Table 11 Rubber clones and tapping systems on yield (kg/ha/y) in the 2nd year of tapping

Tapping system	Tapping day	Yield (kg/ha/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	97	2,386 a	1,409 b	1,621 b	1,805
B. S/3 d1 2d/3	130	2,371 a	1,516 b	1,560 b	1,816
C. S/2 d3 ET 2.5 % 4-5/y	67	2,006 a	1,082 c	1,416 b	1,501
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	72	2,037 a	1,171 c	1,493 b	1,567
average		2,200 a	1,294 c	1,523 b	
CV a (%) = 14.2		CV b (%)	10.8		

Table 12 Rubber clones and tapping systems on bark consumption (cm per year) in the 2nd year of tapping

Tapping system	Tapping day	bark consumption (cm/year)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	97	18.71 b	18.77 b	19.79 b	19.10 b
B. S/3 d1 2d/3	130	25.66 b	26.71 b	26.70 b	26.35 b
C. S/2 d3 ET 2.5 % 4-5/y	67	14.51 a	16.30 a	14.14 a	15.00 a
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	72	16.19 a	17.16 a	14.59 a	16.00 a
average		18.77	19.74	18.80	
CV a (%) = 12.5		CV b (%) =	11.5		

Table 13 Rubber clones and tapping systems on latex diagnosis in the 2nd year of tapping

Tapping system	DRC (Dry rubber content, %)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	47.73	42.04	45.54	45.10
B. S/3 d1 2d/3	45.22	47.91	44.16	45.76
C. S/2 d3 ET 2.5 % 4-5/y	45.46	45.69	47.02	46.05
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	47.02	44.49	45.26	45.59
average	46.35	45.03	45.49	
CV a (%) =13.2	CV b (%)	9.8		

Table 14 Rubber clones and tapping systems on latex diagnosis in the 2nd year of tapping

Tapping system	Sucrose ([Suc], mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	7.49 b	9.79 b	7.23 b	8.17
B. S/3 d1 2d/3	11.28 a	8.35 b	11.34 a	10.32
C. S/2 d3 ET 2.5 % 4-5/y	12.43 a	8.29 b	9.22 b	9.98
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	13.00 a	8.34 b	12.58 a	10.30
average	11.05 a	7.94 b	10.09 a	
CV a (%) =11.2	CV b (%)	8.8		

Table 15 Rubber clones and tapping systems on latex diagnosis in the 2nd year of tapping

Tapping system	Inorganic phosphorus (Pi, mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	12.72	16.48	21.02	16.74
B. S/3 d1 2d/3	15.30	13.38	19.68	16.12
C. S/2 d3 ET 2.5 % 4-5/y	18.01	16.48	19.22	17.90
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	14.59	16.67	12.83	14.70
average	15.16	15.75	18.19	
CV a (%) =12.5	CV b (%)	9.4		

Table 16 Rubber clones and tapping systems on latex diagnosis in the 2nd year of tapping

Tapping system	Thiol ([RSH] mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	0.39	0.49	0.59	0.49
B. S/3 d1 2d/3	0.55	0.48	0.52	0.52
C. S/2 d3 ET 2.5 % 4-5/y	0.56	0.46	0.50	0.51
D. S/2 d3 ET 2.5 % 3-4/y recover tapping day	0.75	0.55	0.48	0.59
average	0.56	0.50	0.52	
CV a (%) =14.5	CV b (%)	11.2		

Table 17 Rubber clones and tapping systems on yield (g/t/t) in the 3rd year of tapping

Tapping system	Tapping	Yield (g/t/t)			average
	day	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	98	48.22 b	34.70 c	37.62 b	40.18 a
B. S/3 d1 2d/3	134	34.77 c	25.26 d	34.36 c	29.35 b
C. S/2 d3 ET 2.5 % 5-6/y	71	62.45 a	32.75 c	39.36 b	44.85 a
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	80	55.79 a	31.89 c	42.02 b	43.23 a
average		50.31 a	31.15 c	36.75 b	
CV a (%) = 12.5		CV b (%) =	9.6		

Table 18 Rubber clones and tapping systems on yield (kg/t/y) in the 3rd year of tapping

Tapping system	Tapping day	Yield (kg/t/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	98	4.73 a	3.40 b	3.69 b	3.94
B. S/3 d1 2d/3	134	4.66 a	3.38 b	3.75 b	3.93
C. S/2 d3 ET 2.5 % 5-6/y	71	4.43 a	2.33 c	2.79 b	3.18
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	80	4.46 a	2.55 c	3.36 b	3.46
average		4.57 a	2.92 c	3.40 b	
CV a (%) = 10.6		CV b (%) =	9.6		

Table 19 Rubber clones and tapping systems on yield (kg/ha/y) in the 3rd year of tapping

Tapping system	Tapping day	Yield (kg/ha/y)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	98	2,215 a	1,594 b	1,728 b	1,846 a
B. S/3 d1 2d/3	134	2,184 a	1,586 b	1,760 b	1,843 a
C. S/2 d3 ET 2.5 % 5-6/y	71	2,078 a	1,090 c	1,310 bc	1,493 b
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	80	2,092 a	1,196 c	1,576 b	1,621 ab
average		2,142 a	1,367 c	1,593 c	-
CV a (%) = 13.5		CV b (%) =	11.7		

Table 20 Rubber clones and tapping systems on bark consumption (cm per year) in the 3rd year of tapping

Tapping system	Tapping day	bark consumption (cm/year)			average
		RRIT 251	RRIM 600	PB 235	
A. S/2 d2	98	19.12 b	18.76 b	18.23 b	18.70 b
B. S/3 d1 2d/3	134	23.73 c	25.02 c	18.42 b	23.62 c
C. S/2 d3 ET 2.5 % 5-6/y	71	13.50 a	14.05 a	14.16 a	15.73 a
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	80	15.75 a	15.52 a	15.91 a	13.90 a
average		18.02	16.68	18.34	
CV a (%) = 12.2		CV b (%) =	10.5		

Table 21 Rubber clones and tapping systems on latex diagnosis in the 3rd year of tapping

Tapping system	DRC (Dry rubber content, %)			Average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	48.33	44.18	47.23	46.58
B. S/3 d1 2d/3	38.29	48.40	45.50	44.06
C. S/2 d3 ET 2.5 % 5-6/y	41.30	45.18	46.49	44.32
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	47.76	47.06	42.89	45.90
average	43.92	46.20	45.53	
CV a (%) =13.2	CV b (%)	9.8		

Table 22 Rubber clones and tapping systems on latex diagnosis in the 3rd year of tapping

Tapping system	Sucrose ([Suc], mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	7.89 b	4.99 c	8.83 ab	7.24
B. S/3 d1 2d/3	10.69 a	7.12 b	12.25 a	10.02
C. S/2 d3 ET 2.5 % 5-6/y	9.77 a	6.17 b	12.04 a	9.33
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	8.86 ab	7.19 b	10.58 a	8.88
average	9.30 a	6.37 b	10.93 a	
CV a (%) =11.2	CV b (%)	8.7		

Table 23 Rubber clones and tapping systems on latex diagnosis in the 3rd year of tapping

Tapping system	Inorganic phosphorus (Pi, mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	23.91	21.20	23.09	22.73
B. S/3 d1 2d/3	22.81	21.43	29.48	24.58
C. S/2 d3 ET 2.5 % 5-6/y	25.73	17.45	27.80	23.66
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	23.59	21.76	24.26	23.20
average	24.01	20.46	26.16	
CV a (%) =12.5	CV b (%)	7.9		

Table 24 Rubber clones and tapping systems on latex diagnosis in the 3rd year of tapping

Tapping system	Thiol ([RSH] mM/l)			average
	RRIT 251	RRIM 600	PB 235	
A. S/2 d2	0.18	0.15	0.19	0.17
B. S/3 d1 2d/3	0.19	0.19	0.26	0.21
C. S/2 d3 ET 2.5 % 5-6/y	0.20	0.15	0.19	0.18
D. S/2 d3 ET 2.5 % 4-5/y recover tapping day	0.23	0.14	0.13	0.16
average	0.20	0.16	0.19	
CV a (%) =14.5	CV b (%)	9.6		